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Other Insecticides, Acaricides, and Repellents[1]

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This section concerns insecticides, acaricides, and repellents having toxicologic characteristics distinct from the insecticides discussed elsewhere. It discusses pyrethroids, fluorides, borates, chlordimeform, propargite, substituted haloaromatic urea compounds, chlorobenzilate, cyhexatin, methoprene, sulfur, diethyltoluamide, alkyl phthalates, and benzyl benzoate.

PYRETHROIDS

Pyrethroids are modern synthetic insecticides that are similar chemically to natural pyrethrins, but modified to increase stability in the natural environment. They are now widely used in agriculture, in homes and gardens, and for treatment of ectoparasitic disease.

Commercial Products

The following list includes the names of several pyrethroids that are not currently in commercial production. These are included because they may be marketed in the future, if not in the United States, then possibly in other countries.

Allethrin (Pynamin), alphametrin, barthrin, bioresmethrin, biopermethrin, cismethrin, cyclethrin, cyfluthrin (Baythroid), cypermethrin (Ammo, Barricade, CCN52, Cymbush, Cymperator, Cyperkill, Folcord, KafilSuper, NRDC 149, Polytrin, Siperin, Ripcord, Flectron, Ustaad, Cyrux), deltamethrin (decamethrin, Decis), dimethrin, fenpropathrin (Danitol, Herald, Meothrin, Ortho Danitol, Rody), fenvalerate (Pydrin, Belmark, Sumicidin, Fenkill), flucythrinate (AASTAR, Pay-off), fluvalinate (Mavrik, Mavrik Aquaflow, Spur), furethrin, indothrin, permethrin (Ambush, BW-21-Z, Ectiban, Eksmin, Kafil, Permasect, Perthrine, Pounce, Pramex, Outflank, Talcord), phthalthrin (Neopynamin), resmethrin (Benzofuroline, Chrysron, Pynosect, Synthrin), tetramethrin (Neopynamin, Phthalthrin), tralomethrin (Scout), esfenvalerate (Asana).

Pyrethroids are formulated as emulsifiable concentrates, wettable powders, granules, and concentrates for ultra low volume application. They may be combined with additional pesticides (sometimes highly toxic) in the technical product or tank mixed with other pesticides at the time of application. AASTAR is a combination of flucythrinate and phorate. Phorate is a highly toxic organophosphate. Nix is 1% permethrin creme applied to control human ectoparasites.

Toxicology of Pyrethroids

Although certain pyrethroids exhibit striking neurotoxicity in laboratory animals when administered by intravenous injection, and some are toxic by the oral route, systemic toxicity by inhalation and dermal absorption is low. There have been very few systemic

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poisonings of humans by pyrethroids. Although limited absorption may account for the low toxicity of some pyrethroids, rapid biodegradation by mammalian liver enzymes (ester hydrolysis and oxidation) is probably the major factor responsible. Most pyrethroid metabolites are promptly excreted, at least in part, by the kidney.

Extraordinary absorbed doses may rarely cause incoordination, tremor, salivation, vomiting, diarrhea, and irritability to sound and touch. Extreme doses have caused convulsions in laboratory animals.

Apart from systemic neurotoxicity, some pyrethroids do cause distressing paresthesia when liquid or volatilized materials contact human skin. Sensations are described as stinging, burning, itching, and tingling, progressing to numbness. The skin of the face seems to be most commonly affected, but the neck, forearms, and hands are sometimes involved. Sweating, exposure to sun or heat, and application of water enhance the disagreeable sensations. Sometimes the effect is noted within minutes of exposure, but a 1-2 hour delay in appearance of symptoms is more common. Sensations rarely persist more than 24 hours. Little or no inflammatory reaction is apparent where the paresthesia are reported; the effect is presumed to result from pyrethroid contact with sensory nerve endings in the skin. Not all pyrethroids cause a marked paresthetic reaction: it is prominent following exposure to pyrethroids whose structures include cyano-groups: fenvalerate, flucythrinate, cypermethrin, and fluvalinate. The paresthetic reaction is not allergic in nature: sensitization does not occur. Neither race, skin type, nor disposition to allergic disease affect the likelihood or severity of the reaction.

Persons treated with permethrin for lice or flea infestations sometimes experience itching and burning at the site of application, but this is chiefly an exacerbation of sensations caused by the parasites themselves, and is not typical of the paresthetic reaction described above.

The manifestations of neurologic disorder seen in laboratory animals given the more toxic pyrethroids in large doses are salivation, irritability, tremors, ataxia, choreoathetosis (writhing convulsions), fall in blood pressure, and death. Severe metabolic acidosis is characteristic.

Due to the inclusion of unique solvent ingredients, certain formulations of fluvalinate are corrosive to the eyes (see Treatment, section 2).

Pyrethroids are not cholinesterase inhibitors.

Treatment of Pyrethroid Toxicosis

1. Skin contamination should be removed promptly by washing with soap and water. If irritant or paresthetic effects occur, treatment by a physician should be obtained. Because volatilization of pyrethroid apparently accounts for paresthesia affecting the face, strenuous measures should be taken (ventilation, protective face mask and hood) to avoid vapor contact with the face and eyes. Vitamin E Oil preparations (di-alpha tocopheryl acetate) are uniquely effective in preventing and stopping the paresthetic reaction. They are safe for application to the skin under field conditions. Corn oil is somewhat effective, but possible side effects with continuing use make it less suitable. Vaseline is less effective than corn oil and zinc oxide actually worsens the reaction.

2. Eye contamination should be treated immediately by prolonged flushing of the eye with copious amounts of clean water or saline. If irritation persists, professional ophthalmologic care should be obtained. Undiluted Mavrik 2E (a formulation of fluvalinate) is corrosive to the eyes. Extraordinary measures should be taken to avoid eye and skin contamination with this product. Should accidental eye contamination occur, expert ophthalmologic care should be obtained after flushing the eye free of the chemical with copious amounts of clean water.

3. Ingestion of pyrethroid insecticide presents relatively little risk. However, if large amounts have been ingested, empty the stomach by ***intubation***, ***aspiration*** **and** ***lavage*** (see Organophosphate Insecticides, Treatment, Section 6). Based on observations in laboratory animals, large ingestions of either allethrin, cismethrin, fenvalerate, or deltamethrin would be the most likely to generate neurotoxic manifestations.

4. If only small amounts of pyrethroid have been ingested, or if treatment has been delayed, oral administration of activated charcoal and cathartic probably represents optimal management (see Organophosphate Insecticides, Treatment, Section 6 for dosages).

5. Several drugs are effective in relieving the pyrethroid neurotoxic manifestations observed in deliberately poisoned laboratory animals. None have been tested in human poisonings; therefore, neither efficacy nor safety under these circumstances is known. Furthermore, moderate neurotoxic symptoms and signs are likely to resolve spontaneously if they do occur. Drugs effective in laboratory animals that might be considered for symptomatic treatment are: atropine (relief of salivation), diazepam, and phenobarbital (relief of tremors and convulsions), and mephenesin (relief of all poisoning manifestations, except, sometimes, salivation).

FLUORIDES

- Sodium fluoride is a crystalline mineral once widely used in the United States for control of larvae and crawling insects in homes, barns, warehouses and other storage areas. It is highly toxic to all plant and animal life.
  - **Commercial product:** Florocid
- Sodium fluosilicate (sodium silico fluoride) has been used to control ectoparasites on livestock, as well as crawling insects in homes and work buildings. It is approximately as toxic as sodium fluoride.
  - **Commercial products:** Safsan (dust formulation), Prodan (bait formulation)
- Sodium fluoaluminate (sodium aluminofluoride, cryolite) is a stable mineral containing fluoride. It is used as an insecticide on some vegetables and fruits. Cryolite has very low water solubility, does not yield fluoride ion on decomposition, and presents very little toxic hazard to mammals, including man.
  - **Commercial product:** Kryocide
- Hydrofluoric acid is an important industrial toxicant, but is not used as a pesticide. Fluoroacetate is discussed with Rodenticides. Sulfuryl fluoride is discussed with Fumigants.

Toxicology and Manifestations of Poisoning by Fluoride

Sodium fluoride and fluosilicate used as insecticides present a serious toxic hazard to humans because of high inherent toxicity, and the possibility that children crawling on floors of treated dwellings will ingest the material.

Absorption across the skin is probably slight, and methods of pesticide use rarely include a hazard of inhalation, but uptake of ingested fluoride by the gut is efficient and potentially lethal. Excretion is chiefly in the urine: renal clearance of fluoride from the blood is rapid. However, large loads of absorbed fluoride poison renal tubule cells. Functional tubular disturbances and sometimes acute renal failure result.

The toxic effects of fluoride in mammals are multiple and all may threaten life. Except for the direct effect on ionized calcium in extracellular fluid, the actions of fluoride result from the inhibition of critical intracellular enzymes.

Ingested fluoride has a corrosive effect on the epithelial lining of the gastrointestinal tract, due, in part, to highly corrosive hydrofluoric acid formed in the stomach. Edema, ulceration, and hemorrhage commonly result. Thirst, abdominal pain, vomiting, and diarrhea, with blood in the vomitus and feces usually occur.

Absorbed fluoride ion reduces extracellular fluid concentrations of calcium and magnesium. Hypocalcemia sometimes results in tetany. Hyperkalemia is sometimes a serious threat to the heart.

Cardiac arrhythmias and shock are often prominent features of poisoning. These probably result from combinations of effects of fluid and electrolyte disturbances and direct actions of fluoride on heart and vascular tissues. Hypotension and severe arrhythmias, sometimes progressing to ventricular fibrillation, characterize severe poisonings.

Toxic actions on the brain are manifest as headache, muscular weakness, salivation, nystagmus, dilated pupils, lethargy, stupor and coma.

Occasionally, convulsions occur. Respiratory failure is usually the immediate cause of death.

Confirmation of Poisoning

Plasma inorganic fluoride concentrations in the general United States population are usually less than 0.02 milligram per liter and rarely above 0.10 milligram per liter. In fatal cases of poisoning, plasma levels from 3.5 to 15.5 milligrams per liter have been recorded.

Treatment of Fluoride Toxicosis

1. Contamination of the skin should be removed by washing with soap and water. Eye contamination should be removed by prolonged flushing of the eye with copious amounts of clean water or saline. If irritation persists, specialized medical treatment should be obtained.

2. If ***sodium fluoride*** **or** ***sodium fluosilicate*** has been ***ingested***, immediate steps must be taken to remove or neutralize the toxicant.

    a. If the victim is fully alert, and if vomiting does not totally prevent swallowing of a neutralizing agent, prompt oral administration of lime water (0.15% calcium hydroxide), 1% calcium chloride solution, calcium- or magnesium-based antacid or aluminum hydroxide gel (antacid gel preparation), or milk will precipitate the bulk of fluoride ion in the gut and therefore may be lifesaving. The victim should be given as much as can be tolerated.

    b. If the victim is obtunded or if vomiting precludes oral administration, the airway should be protected by endotracheal intubation, then the stomach should gently be intubated and lavaged with several ounces of one of the liquids named in 2A above. Activated charcoal does not bind fluoride ion and is therefore of no value in fluoride poisoning.

3. A blood specimen should be drawn for blood electrolyte analysis: sodium, potassium, calcium, magnesium, fluoride, and bicarbonate capacity. Another sample should be drawn to type and cross-match for blood transfusion. Intravenous liquids (initially 5% dextrose in 0.9% saline) should be started to combat dehydration, shock and metabolic acidosis. Fluid balance should be monitored closely to forestall fluid overload if renal failure occurs. If metabolic acidosis is detected, sodium bicarbonate should be administered to keep the urine at pH 7.0-7.5. Intravenous fluids must be stopped if anuria or oliguria (less than 25-30 ml per hour) develops. If urine formation declines, extracorporeal hemodialysis should be used. It removes fluoride efficiently but no more rapidly than a normally functioning kidney.

4. Monitor cardiac status by continuous electrocardiography. Ventricular arrhythmias may necessitate DC cardioversion.

5. If overt or latent (Chvostek's sign) tetany occurs, or if hypocalcemia is demonstrated, or if it appears likely that a significant amount of fluoride has been absorbed, administer 10 ml of 10% **calcium gluconate** intravenously, at no more than one ml per minute. Initial children's dose is approximately 0.5 ml/kg body weight. Repeat in 10-20 minutes if there are still indications of hypocalcemia. Severe poisonings may require administration of several hundred millimeters of 10% calcium gluconate.

6. ***Oxygen*** by mask should be administered for hypotension, shock, cardiac arrhythmias, or cyanosis. Shock may require administration of plasma or blood.

Sodium fluoaluminate **(cryolite)** is much less toxic than other fluorides. If a very large amount has been ingested, it may be appropriate to measure serum calcium to insure that hypocalcemia has not occurred. If so, intravenous 10% calcium gluconate would be indicated (see 5 above). It is unlikely that treatment for fluoride toxicity would be necessary following ingestion of sodium fluoaluminate.

BORIC ACID AND BORATES

Formulated as tablets and powder to kill larvae in livestock confinement areas and cockroaches in residences. Rarely, solutions are sprayed as a nonselective herbicide.

Boric acid, sodium tetraborate decahydrate (borax), sodium pentaborate, boron trioxide, sodium biborate.

Commercial products: Polybor, Pyrobor

Toxicology and Manifestations of Poisoning by Borate

Borax dust is moderately irritating to skin. Inhaled dust causes irritation of the respiratory tract: cough and shortness of breath.

There have been few poisonings from the pesticidal uses of borates, although powders and pellets scattered on the floors of homes do present a hazard to children. Most poisonings have resulted from injudicious uses in human medicine aimed at suppressing bacterial growth, such as compresses for burns. Many poisonings of newborns occurred in the 1950s and 1960s.

Borates are well absorbed by the gut and by abraded or burned skin, but not by intact skin. They are efficiently excreted by the kidney. The residence half-life in humans averages 13 hours, in a range of 4-28 hours.

The gastrointestinal tract, skin, vascular system, and brain are the principal organs and tissues affected. Nausea, persistent vomiting, abdominal pain, and diarrhea reflect a toxic gastroenteritis, which occurs even when the borate was absorbed across damaged skin. Blood in vomitus and feces reflect hemorrhagic lesions in the gut mucosa. In severe poisonings of infants, a beefy red skin rash, most often affecting palms, soles, buttocks, and scrotum, has been described. It has been characterized as a "boiled lobster appearance." The intense erythema is followed by extensive exfoliation.

Cyanosis, weak pulse, and cold clammy skin indicate shock, which is sometimes the cause of death in borate poisoning.

Headache, weakness, lethargy, restlessness, and tremors may progress to intermittent seizures. Unconsciousness and respiratory depression signify life-threatening brain injury.

Acute renal failure (oliguria or anuria) may be a consequence of shock, of direct toxic action on renal tubule cells, or both. It occurs only in severe borate poisoning. Metabolic acidosis may be a consequence of the acid itself, of seizure activity, or of metabolic derangements. Fever is sometimes present in the absence of infection.

A recent analysis of 784 cases of ***acute single-dose borate ingestion*** (excluding newborns and cases of protracted exposure) has indicated a much more favorable prognosis than that which was based on neonate poisonings in the 1950s and 1960s (50%-70% mortality). In the recent survey (Litovitz, T.L. et al. *Am. J. Emergency Med.* 6(3):209-213, 1988), only 12% of cases were even symptomatic, and there were no fatalities. In those who became symptomatic, gastrointestinal symptoms (vomiting, abdominal pain, diarrhea) predominated. Central nervous system manifestations and rash were rare and of brief duration when they did occur.

Confirmation of Poisoning

Borate can be measured in serum by a colorimetric procedure, using carminic acid as a chromogen. Blood borate concentrations in non-exposed individuals are in the range of 0.0-7.2 mg per liter (average 1.4 mg per liter). Excluding newborns and chronically exposed individuals, serum borate concentrations less than 340 mg per liter have rarely been associated with significant toxicity.

A paper spot test for borate in the urine may be helpful in identifying urine borate concentrations greater than 20 mg per liter. Urine acidified with hydrochloric acid and applied to tumeric paper produces a brownish-red color if borate is present. A recent evaluation has warned, however, that a significant number of false positives may be encountered when this test is used.

Treatment of Borate Toxicosis

1. Dermal contamination should be removed by washing with soap and water. Contamination of the eye should be treated by prolonged flushing with copious amounts of saline or water. If irritation persists, specialized medical treatment should be obtained.

2. The great majority of pesticidal borate poisonings are likely to be acute (single dose) ingestions and are unlikely to occur in newborns. A recently recommended protocol for management of acute borate ingestion (excluding newborns and chronically exposed persons) is shown in Table 1.

   Dosage of Syrup of Ipecac for adults and children over 12 years is 30 ml; dosage for children under 12 years is 15 ml. Follow Syrup of Ipecac with 2-3 glasses of water. Watch closely for declining

Table 1. Recommended Protocol for Management of Acute Borate Ingestion

Patient's Weight, kg	Dose of Borate	Recommended Management
Less than 30 kg	Less than 200 mg/kg	Observation only
	200 - 400 mg/kg	Syrup of Ipecac
	Greater that 400 mg/kg	Syrup of Ipecac or gastric lavage
Greater than 30 kg	Less than 6.0 gm	Observation only
	6.0 - 12.0 gm	Syrup of Ipecac
	Greater thatn 12.0 gm	Syrup of Ipecac or gastric lavage

consciousness level; insure that the victim is in a head down left lateral decubitus position when vomiting occurs. Protocol for gastric lavage is set forth in the section on Organophosphate Insecticides, Treatment, Section 6. Activated charcoal does not absorb borate and therefore should not be given unless an additional toxicant was ingested which is charcoal-adsorbable.

Obtain a blood sample 2-3 hours post-ingestion to assess severity of poisoning, but do not base initial therapy on blood concentration.

3. If ***ingestion*** of borate has been ***massive*** (several grams), or has extended over several days, administer intravenous glucose and electrolyte solutions to sustain urinary excretion of borate. Monitor fluid balance and blood electrolytes (including bicarbonate capacity) regularly. Monitor cardiac status by ECG. Test the urine for protein and cells to detect renal injury, and monitor serum concentration of borate. If metabolic acidosis is detected, sodium bicarbonate should be added to the infused fluids to keep urine pH in the 7.0-7.5 range. If shock develops, it may be necessary to infuse plasma or whole blood. Administer oxygen continuously. If oliguria (less than 25-30 ml urine formed per hour) occurs, intravenous fluids must be slowed or stopped to avoid overloading the circulation.

   a. Both peritoneal dialysis and extracorporeal hemodialysis have been used with apparent success in accelerating elimination of borate. If renal failure occurs, hemodialysis may be necessary to sustain fluid balance and normal extracellular fluid composition. In poisoned infants, exchange blood transfusion has been used successfully.

   b. Control convulsions with benzodiazepine drugs or other anticonvulsants, if necessary (see Solid Organochlorine Insecticides, Treatment, Section 4).

CHLORDIMEFORM

Formulations are emulsifiable concentrates and water-soluble powders. Chlordimeform is an ovicide and acaricide.

Commercial Products: Bermat, Fundal, Galecron, Ovatoxin.

Toxicology and Manifestations of Poisonings by Chlordimeform

In a reported episode of occupational exposure to chlordimeform, several workers developed hematuria. Hemorrhagic cystitis, probably due to chloraniline biodegradation products, was the source of the blood in the urine. Symptoms reported by the affected workers were: gross blood in the urine, painful urination, urinary frequency and urgency, penile discharge, abdominal and back pain, a generalized "hot" sensation, sleepiness, skin rash and desquamation, a sweet taste, and anorexia. Symptoms persisted for 2-8 weeks after exposure was terminated.

Chlordimeform is not a cholinesterase inhibitor. Although methods do exist for measurement of urinary excretion products, these tests are not generally available.

Treatment of Chlordimeform Toxicosis

Strenuous efforts should be made to protect against inhalation and dermal contact with chlordimeform because absorption is evidently efficient. Skin contamination should be washed off with soap and water. Contamination of the eye

should be treated by flushing with copious amounts of clean water or saline. If irritation persists, specialized medical treatment should be obtained.

If chlordimeform has been ingested no more than several hours prior to treatment, and if the patient is fully alert, administer Syrup of Ipecac, followed by several glasses of water, to empty the stomach. Dosage for adults and children over 12 years: 30 ml; dosage for children under 12 years: 15 ml.

If the patient is obtunded, the operation of a different or additional toxicant should be suspected. In this event, the stomach should be emptied by intubation, aspiration, and lavage with a slurry of activated charcoal in water or saline, after measures have been taken to protect the respiratory tract from aspiration of gastric contents (see Organophosphate Insecticides, Treatment, Section 6).

After the stomach has been emptied, activated charcoal and a cathartic should be administered (see above reference). Repeated doses of charcoal every 2-4 hours may be beneficial. Because catharsis may cause serious dehydration and electrolyte disturbances in young children, fluid balance and serum electrolytes should be monitored. An adequate state of hydration should be maintained by oral and/or intravenous fluids to support chlordimeform excretion.

Repeated analyses of urine for protein and red cells should be done to detect injury to the urinary tract. Disappearance of hematuria can ordinarily be expected in 2-8 weeks. Relief from other symptoms can usually be expected earlier.

PROPARGITE

Formulations are wettable powders and emulsifiable concentrates. Propargite is an acaricide with residual action.

Commercial Products: Omite, Comite, Uniroyal D014.

Toxicology and Adverse Effects of Propargite

Propargite exhibits very little systemic toxicity in animals. No systemic poisonings have been reported in humans. However, many workers having dermal contact with this acaricide have experienced skin irritation and possibly sensitization in some cases. Eye irritation has also occurred. For this reason, stringent measures should be taken to prevent inhalation or any skin or eye contamination by propargite.

There is no readily available method for detecting propargite absorption.

Treatment of Propargite Toxicosis

Skin contamination should be removed by prompt washing with soap and water. Eye contamination should be treated by flushing with copious amounts of clean water or saline. If irritation persists, specialized medical treatment should be obtained. Sensitization reactions may require steroid therapy.

If large amounts of propargite have been ingested, and effective vomiting has not occurred, and if there are no indications of nervous system depression, administration of Syrup of Ipecac, followed by several glasses of water, is probably the appropriate method to empty the stomach. Dosage for adults and children over 12 years: 30 ml; dosage for children under 12 years: 15 ml.

If there are indications of central nervous system depression, empty the stomach by intubation, aspiration, and lavage with a slurry of activated charcoal, having first taken precautions to prevent aspiration of stomach contents (see Organophosphate Insecticides, Treatment, Section 6). Follow the lavage with installation of activated charcoal (see above reference). Include sorbitol in the charcoal installation if diarrhea has not already commenced.

If the amount of propargite ingested was small, or if treatment is delayed, oral administration of activated charcoal and sorbitol probably represents optimal management.

DIFLUBENZURON

This is a haloaromatic substituted urea which controls insects by impairing chitin deposition in the larval exoskeleton. It is formulated in wettable powders, oil dispersible concentrate, and granules for use in agriculture and forestry and in settings where fly populations tend to be large, such as feedlots.

Commercial Products: Dimilin, Micromite

Toxicology of Diflubenzuron

There is limited absorption across the skin and intestinal lining of mammals, after which enzymatic hydrolysis and excretion rapidly eliminate the pesticide from tissues. Irritant effects are not reported and systemic toxicity is low. Methemoglobinemia is a theoretical risk from chloroaniline formed hydrolytically, but no reports of this form of toxicity have been reported in humans or animals from diflubenzuron exposure.

Treatment of contamination and ingestion should proceed essentially as with propargite. Skin contamination should be removed by prompt washing with soap and water. Eye contamination should be treated by flushing with copious amounts of clean water or saline. If irritation persists, specialized medical treatment should be obtained. Sensitization reactions may require steroid therapy.

If large amounts of diflubenzuron have been ingested, and effective vomiting has not occurred, and if there are no indications of nervous system depression, administration of Syrup of Ipecac, followed by several glasses of water, is probably the appropriate method to empty the stomach. Dosage for adults and children over 12 years: 30 ml; dosage for children under 12 years: 15 ml.

If there are indications of central nervous system depression, empty the stomach by intubation, aspiration, and lavage with a slurry of activated charcoal, having first taken precautions to prevent aspiration of stomach contents (see Organophosphate Insecticides, Treatment, Section 6). Follow the lavage with installation of activated charcoal (see above reference). Include sorbitol in the charcoal installation if diarrhea has not already commenced.

If the amount of diflubenzuron ingested was small, or if treatment is delayed, oral administration of activated charcoal and sorbitol probably represents optimal management.

TEFLUBENZURON

This is another haloaromatic substituted urea insecticide, apparently similar in toxicologic properties to diflubenzuron. Low systemic toxicity is reported.

Commercial Products: Nomolt, Dart, Diaract

CHLOROBENZILATE

Chlorobenzilate is a chlorinated hydrocarbon acaricide, usually formulated as an emulsion or wettable powder for application in orchards. It is presently a **Restricted Use Pesticide** because of neoplastic effects observed in laboratory animals subjected to high dosage over long periods.

Commercial Products: Acaraben, Akar, Folbex, Benzilan.

Toxicology of Chlorobenzilate

Chlorobenzilate is moderately irritating to the skin and eyes.

Although structurally similar to DDT, chlorobenzilate is much more rapidly excreted following absorption, chiefly in the urine as the benzophenone and benzoic acid derivatives. No systemic poisonings of humans have been reported. Based on observation of dosed animals, extreme absorbed doses may cause tremor, ataxia, and muscle weakness.

Chlorobenzilate is not a cholinesterase inhibitor.

Treatment of Chlorobenzilate Exposure

Remove skin contamination by washing with soap and water. Remove eye contamination by flushing with clean saline or water. If irritation persists, medical attention must be obtained.

If a large amount of chlorobenzilate was ingested within a few hours prior to treatment, and if there are no indications of central nervous system disturbance, empty the stomach by administering Syrup of Ipecac followed by several glasses of water. Dosage for adults and children over 12 years: 30 ml; dosage for children under 12 years: 15 ml.

After vomiting stops, administer activated charcoal and sorbitol orally (for dosage, see Organophosphate Insecticides, Treatment, Section 6).

If there are any indications of central nervous system disturbance (depression, ataxia, tremor), empty the stomach by intubation, aspiration, and lavage, after first taking all precautions to protect the respiratory tract from aspiration of gastric contents (see above reference). Lavage the stomach with a slurry of activated charcoal. Leave charcoal and an

appropriate dose of sorbitol in the stomach before withdrawing the lavage tube.

If the absorbed dose of chlorobenzilate was small, if treatment is delayed, and if the patient is asymptomatic, oral administration of activated charcoal and sorbitol is probably the optimal management (see above reference for dosage). Do not give fats or oils.

CYHEXATIN

Commercial product: Plictran.

Toxicology of Cyhexatin and Treatment of Toxicosis

Tricyclohexyl tin hydroxide is formulated as a 50% wettable powder for control of mites on ornamentals, hops, nut trees, and some fruit trees. It is moderately irritating, particularly to the eyes. While information on the systemic toxicity of this specific tin compound is lacking, it should probably be assumed that cyhexatin can be absorbed to some extent across the skin, and that substantial absorbed doses would cause nervous system injury (see Organotin Compounds in the Fungicides section). Accordingly, dermal contamination should be promptly removed by washing with soap and water, and contamination of the eyes should be treated by prolonged flushing with clean water or saline. Management of poisonings by ingestion should proceed on the assumption that cyhexatin is highly toxic, even though rodent LD_{50} values are fairly high, and no human poisonings have been reported. See Organophosphate Insecticides, Treatment, Section 6 concerning measures to limit toxicant absorption from the gut. Neither BAL, penicillamine nor chelating agents have been effective in lowering tissue stores of organic tin compounds in experimental animals.

METHOPRENE

Methoprene is a long chain hydrocarbon ester active as an insect growth regulator. It is effective against several insect species. Formulations include slow-release briquets, sprays, foggers, and baits.

Commercial Products: ZR-515, Altosid SR-10 and CP-10, Apex 5E, Diacon, Dianex, Kabat, Minex, Pharorid, Precor.

Toxicology of Methoprene

Methoprene is neither an irritant nor a sensitizer in humans or laboratory animals.

Systemic toxicity in laboratory animals is very low. No human poisonings or adverse reactions in exposed workers have been reported.

Treatment of Methoprene Toxicosis

Wash contaminated skin with soap and water. Flush contamination from eyes with copious amounts of clean water or saline. If irritation persists, medical attention must be obtained.

If a very large amount of methoprene has been ingested, oral administration of charcoal may be considered. The hazards of catharsis (dehydration, electrolyte disturbances) probably outweigh the hazards of methoprene.

SULFUR

Elemental sulfur is an acaricide and fungicide widely used on orchard, ornamental, vegetable, grain, and other crops. It is prepared as dust in various particle sizes and applied as such, or it is formulated with various minerals to improve flowability, or is applied as an aqueous emulsion or wettable powder.

Commercial Products: Brimstone, Lacco Sulfur, Clifton Sulfur, Sul-Cide, Cosan, Kumulus S, Sofril, Sulfex, Thiolux, Thiovit, Magnetic 6, Liquid Sulfur, Thion, Zolvis, Golden Dew.

Toxicology of Sulfur

Elemental sulfur is moderately irritating to the skin, and airborne dust is irritating to the eyes and the respiratory tract. In hot sunny environments, there may be some oxidation of foliage-deposited sulfur to irritating gaseous sulfur oxides, which are very irritating to the eyes and respiratory tract.

Ingested sulfur powder induces catharsis, and has been used medicinally (usually with molasses) for that purpose. Some hydrogen sulfide is formed in the large intestine and this may present a degree of toxic hazard. However, an adult has survived ingestion of 60 grams.

Ingested colloidal sulfur is efficiently absorbed by the gut and is promptly excreted in the urine as inorganic sulfate.

Treatment of Sulfur Toxicosis

Skin contamination should be removed by washing with soap and water. Contamination of the eyes should be removed by prolonged flushing with clean saline or water. If irritation persists, medical attention should be obtained.

Unless an extraordinary amount of sulfur (several grams) has been ingested shortly prior to treatment, there is probably no need for emptying the stomach or administration of a cathartic. Adsorbability of sulfur on activated charcoal has not been tested.

The most serious consequence of sulfur ingestion is likely to be that of catharsis: dehydration and electrolyte depletion, particularly in children. If diarrhea is severe, oral or intravenous administration of glucose and/or electrolyte solutions may be appropriate.

DIETHYLTOLUAMIDE (DEET)

This chemical is a widely used insect repellent, suitable for application to skin or to fabrics. It is formulated with ethyl or isopropyl alcohol, usually in pressurized containers.

Commercial Products: Detamide, Metadelphene, MGK, OFF.

Toxicology of DEET

For many years, diethyltoluamide has been effective and generally well tolerated applied to human skin, although tingling, mild irritation, and sometimes desquamation have followed repeated application. In some cases, DEET has caused contact dermatitis and exacerbation of preexisting skin disease. It is very irritating to the eyes, but not corrosive.

Serious adverse effects have occurred when used under tropical conditions, when it is applied to areas of the skin that were occluded during sleep (mainly the antecubital and popliteal fossae). Under these conditions, the skin became red and tender, then exhibited blistering and erosion, leaving painful weeping denuded areas that were slow to heal. Permanent scarring resulted from most of these severe reactions.

DEET is efficiently absorbed across the skin and by the gut. Blood concentrations of about 3 mg per liter have been reported several hours after dermal application in the prescribed fashion. Toxic encephalopathic reactions have apparently occurred in rare instances following dermal application, mainly in children who were intensively treated. The more frequent cause of systemic toxicity has been ingestion, deliberate in adults, accidental in young children.

Manifestations of toxic encephalopathy have been behavioral disorders including headache, restlessness, crying spells, mania, stupor progressing to coma, ataxia, hyperreflexia, tachypnea, hypotension, tremors, and writhing convulsions (athetosis). Some cases have shown flaccid paralysis and areflexia. Deaths have occurred following very large doses. Blood levels of DEET found in fatal systemic poisonings have ranged from 168 to 240 milligrams per liter. Interpretation of DEET toxicity in some fatal cases has been complicated by effects of simultaneously ingested ethanol, tranquilizers, and other drugs. One well documented case of anaphylactic reaction to DEET has been reported. One fatal case of encephalopathy in a child heterozygous for ornithine carbamoyl transferase deficiency resembled Reyes syndrome, but the postmortem appearance of the liver was not characteristic of the syndrome.

Discretion should be exercised in recommending DEET for persons who have acne, psoriasis, an atopic predisposition, or other chronic skin condition. It should not be applied to any skin area that is likely to be opposed to another skin surface for a significant period of time (antecubital and popliteal fossae, inguinal areas).

Great caution should be exercised in using DEET on children. Only the products containing the lower concentrations (usually 15%) should be used, and application should be limited to exposed areas of skin, using as little repellent as possible. If continuous repellent protection is necessary, DEET should be alternated with a repellent having another active ingredient. If headache or any kind of emotional or behavioral change occurs, use of DEET should be discontinued immediately.

Confirmation of Diethyltoluamide Poisoning

Methods exist for measurement of DEET in blood and tissues and of metabolites in urine, but these are not widely available.

Treatment of DEET Toxicosis

If a skin reaction occurs, residual DEET should be removed by washing the treated area with soap and water. Eye contamination should be treated by prolonged flushing with clean saline or water. If irritation persists, medical treatment should be obtained.

Steroid or antimicrobial topical medications may be indicated for severe skin reactions that occasionally follow application of DEET.

If a substantial amount of DEET has been ***ingested*** within a few hours of treatment, the stomach should be intubated, aspirated, and lavaged with a slurry of activated charcoal, after every precaution has been taken to protect the airway from aspiration of gastric contents (see Organophosphate Insecticides, Treatment, Section 6). A slurry of charcoal, including an appropriate dose of sorbitol, should be left in the stomach before the tube is withdrawn (see above reference for dosage). If a very large amount of DEET was swallowed, repeated doses of charcoal every 2-4 hours may be beneficial.

If dosage ingested was assuredly small, and the patient is fully alert, oral administration of activated charcoal and sorbitol probably represents optimal management. If diarrhea has already commenced, the sorbitol should be omitted.

Intravenous electrolytes, plasma and/or whole blood may be needed to combat shock in severe poisonings. Administer oxygen continuously by mask if respiratory or circulatory embarrassment is evident. Adrenergic amines may be indicated.

If convulsive activity develops, benzodiazepine or other anticonvulsants may be required (see Solid Organochlorine Insecticides, Treatment, Section 4).

Persons surviving poisoning by ingestion of DEET have usually recovered in 2 to 24 hours.

ALKYL PHTHALATES

Dimethyl phthalate has been widely used as an insect repellent applied directly to the skin. Dibutylphthalate is impregnated into fabric for the same purpose. It is more resistant to laundering than dimethyl phthalate.

Commercial Product: DMP

Toxicology of Alkyl Phthalates

Dimethyl phthalate is strongly irritating to the eyes and mucous membranes. It has caused little or no irritation when applied to skin, and dermal absorption is apparently minimal. It has not caused sensitization.

Tests in rodents have indicated low systemic toxicity, but large ingested doses cause gastrointestinal irritation, central nervous system depression (to coma), and hypotension. One accidental ingestion by a human resulted in coma, but recovery was prompt.

Treatment of Alkyl Phthalate Toxicosis

No antidote is available. Supportive measures (hydration, oxygen if needed) are probably adequate to manage all but the most severe poisonings.

BENZYL BENZOATE: TOXICOLOGY, MANIFESTATIONS, AND TREATMENT

Incorporated into lotions and ointments, this agent has been used for many years in veterinary and human medicine against mites and lice. Apart from occasional cases of skin irritation, adverse effects have been few. The efficiency of skin absorption is not known. Absorbed benzyl benzoate is rapidly biotransformed to hippuric acid which is excreted in the urine. When given in large doses to laboratory animals, benzyl benzoate causes excitement, incoordination, paralysis of the limbs, convulsions, respiratory paralysis, and death. No human poisonings have been reported.

If significant irritant effect appears, medication should be discontinued and the skin cleansed with soap and water. Eye contamination should be treated by prolonged flushing with clean water or saline. If a potentially toxic amount has been swallowed and retained, steps should be taken to remove it from the gastrointestinal tract and repeated doses of activated charcoal should be administered (see

Organophosphate Insecticides, Treatment, Section 6). If seizures occur, control may require anticonvulsant medication (see Solid Organochlorine Insecticides, Treatment, Section 4).